REMARKS

Claims 1 to 12 are currently pending in the present application. Claims 7, 10 and 11 are amended herein for purposes of form. No new matter is added by the amendments.

Claims 1 to 12 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent 6,392,263 Chen et al. (hereinafter "Chen"). Applicants respectfully submit that Chen does not render obvious independent claims 1 and 8 or claims 2 to 7, which depend from claim 1 or claims 9 to 12, which depend from claim 8.

Excessive current leakage from the photosensitive (e.g., photodiode) regions in CMOS image sensors is a significant cause of white pixel problems. It is an object of the present invention to provide an image sensor having a reduced number of white pixels and a reduced fixed pattern noise. Accordingly, claim 1 is directed to an image sensor comprising a semiconductor body having a first conductivity type and having a surface, the surface being provided with a number of cells, a cell comprising a photosensitive element and a reset transistor, the reset transistor comprising a source region, a drain region and a gate region, the source region and the drain region having a second conductivity type opposite to the first, the source region of the reset transistor being electrically connected to the photosensitive element, wherein a well region is present which the well region extends from the surface into the semiconductor body and extends at least partly below the gate region and the well region having a first conductivity type, the source region extending at least substantially in a doped region of the photosensitive element, the doped region having a second conductivity type.

Chen fails to anticipate a cell comprising a photosensitive element and a reset transistor, the reset transistor comprising a source region, a drain region and a gate region, the source region and the drain region having a second conductivity type opposite to the first, the source region of the reset transistor being electrically connected to the

photosensitive element, wherein a well region is present which the well region extends from the surface into the semiconductor body and extends at least partly below the gate region and the well region having a first conductivity type, the source region extending at least substantially in a doped region of the photosensitive element, the doped region having a second conductivity type, as claimed in claim 1. Specifically, Chen fails to disclose a well region which extends from the surface into the semiconductor body and extends at least partly below the gate region and the well region having a first conductivity type, the source region extending at least substantially in a doped region of the photosensitive element, the doped region having a second conductivity type.

The Action cites Chen for disclosing an image sensor such as that disclosed by claim 1 of the instant application. Specifically, the Action cites Fig. 3 of Chen for disclosing a p-type semiconductor body 302, with cells comprising photodectector PD and reset transistor RS at the surface of the body. The Action suggests that the doped region of the photosensitive element is the edge region of the well 305, including presumably the junction depletion region that can extend various distances into the well 305 so that there is no sharp distinction between the photosensitive element, the N-well and the source itself. The Action further suggests that one can regard the doped region of N-well 305 that is between source 307 and the PD as being part of the source or as being part of the photosensitive depletion region. Applicants respectfully submit that Chen fails to disclose a well region extending from the surface into the semiconductor body and extending at least partly below the gate region and the well region having a first conductivity type, the source region extending at least substantially in a doped region of the photosensitive element, the doped region having a second conductivity type, as clearly claimed in claim 1.

There is no teaching in Chen to support the assumption made by the Action that the doped region of the photosensitive element is the edge region of the well 305, including presumably the junction depletion region that can extend various distances into the well 305. Chen merely discloses a well 304 of the conductivity type of the substrate

(a p-well), which surrounds a well of the opposite conductivity type, an n-well 305. Additionally, the assumption made by the Action that one can regard the doped region of N-well 305 that is between source 307 and the PD as being part of the source or as being part of the photosensitive depletion region also lacks support in Chen. Chen simply discloses that the junctions between p-well 304 and n-well 305 are formed by the n-well/p-substrate portion (indicated by depletion region 308 under reverse bias) and the n-well/p-well peripheral portions (indicated by depletion regions 309a and 309b under reverse bias).

Moreover, Chen specifically points out that a junction portion 309a intersects the surface, protected by the insulator 303, along line 306a, while a junction portion 309b intersects the surface under gate oxide 301 along line 306b. In stark contrast, the instant invention seeks to position the source region substantially in the doped region of the photosensitive element, thereby reducing the source-well junction area. Accordingly, the invention of claim 1 is based on the insight that white pixels and fixed pattern noise are mainly caused by the source-well junction. This junction causes large leakage currents due to tunneling of charge carriers through the depletion layer. The tunnel current can be a trap assisted tunnel current or a direct tunnel current. Leakage currents due to tunneling in the source-well junction can be distinguished from regular Shockly-Read-Hall recombination by the exponential behavior of the current as a function of the voltage applied across the junction. A correlation has been found between the exponential behavior of the leakage current in the source-well junction, the number of white pixels and the fixed pattern noise. By positioning the source region substantially in the doped region of the photosensitive element as claimed in claim 1, the source-well junction area is reduced and therefore the number of white pixels and FPN are reduced. The leakage current due to the junction between the source-photosensitive element is almost negligible because the source region and the doped region of the photosensitive element have the same conductivity type. Figure 3 of Chan fails to disclose a source region substantially in the doped region of the photosensitive element that enables a reduction in the source-well junction area, as is clearly claimed in claim 1. To establish prima facie

obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974).

Thus, Chen fails to anticipate all elements of claim 1. Accordingly, for at least these reasons, independent claim 1 is clearly patentable over the cited combination. Claims 2 to 7 depend from claim 1 and thus incorporate the limitations thereof. Accordingly, claims 2 to 7 are patentable over Chen for at least the reasons discussed with respect to claim 1.

Claim 8 is directed to a method of manufacturing a CMOS image sensor comprising the steps of: forming a photosensitive element in a semiconductor substrate having a first conductivity type by providing dopant atoms into a region in the semiconductor substrate, the dopant atoms having a second conductivity type in the region opposite to the first conductivity type, using a protection mask over the region of the photosensitive element after which a well region is formed by implanting ions having a first conductivity type in the semiconductor substrate, forming a gate region by depositing a layer of gate material and patterning the layer, wherein the gate region is formed over a side-wall of the well region, the side-wall being present between the region of the photosensitive element and the well region. Claim 8 is directed to a method of manufacturing an image sensor wherein the gate region is formed over a side-wall of the well region, the side-wall being present between the region of the photosensitive element and the well region. Accordingly, claim 8 claims a method of manufacturing an image sensor having a source region substantially in the doped region of the photosensitive element that enables a reduction in the source-well junction area, as is claimed in claim 1. Thus, claim 8 is patentable over Chen for at least the reasons discussed with respect to claim 1.

Claims 9 to 12 depend from claim 8 and thus incorporate the limitations thereof. Accordingly, claims 9 to 12 are patentable over Chen for at least the reasons discussed with respect to claim 8

Conclusion

In view of the foregoing, Applicants respectfully submit that the specification, the drawings and all claims presented in this application are currently in condition for allowance. Accordingly, Applicants respectfully request favorable consideration and that this application be passed to allowance.

Should any changes to the claims and/or specification be deemed necessary to place the application in condition for allowance, the Examiner is respectfully requested to contact the undersigned to discuss the same.

Applicants' representative believes that this response is being filed in a timely manner. In the event that any extension and/or fee is required for the entry of this amendment the Commissioner is hereby authorized to charge said fee to Deposit Account No. 14-1270. An early and favorable action on the merits is earnestly solicited.

If the Examiner should have any questions concerning this communication or feels that an interview would be helpful, the Examiner is requested to call David Barnes, Esq., Intellectual Property Counsel, Philips North America Corporation at the number below.

Respectfully submitted,

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